JOURNAL OF INFORMATION, KNOWLEDGE AND RESEARCH IN MECHANICAL ENGINEERING
ISSN 0975 – 668X| NOV 15 TO OCT 16 | VOLUME – 04, ISSUE - 01

HEAT TRANSFER ENHANCEMENT BY V-NOZZLE TURBULATORS

Deepali S. Bankar
Lecturer, Automobile Engineering Department
G. H. Raisoni Polytechnic
Nagpur (Maharashtra), India
bankardeepali@gmail.com

Abstract

The effects of V-nozzle inserts on heat transfer and friction characteristics in a uniform heat flux tube are experimentally studied. The V-nozzle with pitch ratio 5.0 used. Experimental investigations have been carried out to study the effects of the V-nozzle turbulators on heat transfer augumentation, friction and enhancement efficiency, in a circular tube. It is found that using the V-nozzle can help to increase considerably the heat transfer rate at about 140% over the plain tube. A maximum gain of 1.19 on enhancement efficiency is obtained for the pitch ratio used, PR=5.0. This indicates that the effect of the reverse/re-circulation flows can improve the heat transfer rate in the tube. In addition, correlations from the results are presented.

Keywords- *Heat transfer enhancement, turbulators, v-nozzle.*

I. INTRODUCTION

Heat transfer enhancement is the process of improving the performance of a heat transfer system. It generally means increasing the heat transfer coefficient. The performance of heat exchanger depends how effectively heat is utilized. The high performance of heat exchangers are very much essential in many practical applications such as aerospace, vehicles, refrigeration and air conditioning, cooling of electric equipment and so on. Reduction of the size of the heat exchanger may be possible due to improvement in the performance of heat exchanger. On the other hand, a high performance heat exchanger of a fixed size can give a increased heat transfer rate and also there is decrease in temperature difference between the process fluids enabling efficient utilization of thermodynamic availability. The performance can be improved by using various augmentation techniques such as finned surfaces, integral roughness and insert devices. A variety of different techniques are employed for the heat transfer process.

Many active and passive techniques are currently being employed in heat exchangers, with twisted tape inserts providing a cost-effective and efficient means of augmenting heat transfer. The reverse flow device or the turbulator is widely employed in heat transfer engineering applications. The reverse flow is sometimes called "re-circulation flow". The effect of reverse flow and boundary layer eruption (dissipation) is to enhance the heat transfer coefficient and momentum transfers. The reverse flow with high turbulent flow can improve convection of

the tube wall by increasing the effective axial Reynolds number, decreasing the cross-section flow area, and increasing the mean velocity and temperature gradient. It can help to produce the higher heat fluxes and momentum transfer due to the large effective driving potential force but also higher pressure drop. The strengths of reverse flow and the reattached position are the main interest in many heat transfer applications such as heat exchangers, combustion chambers, gas turbine blades, and electronic devices.

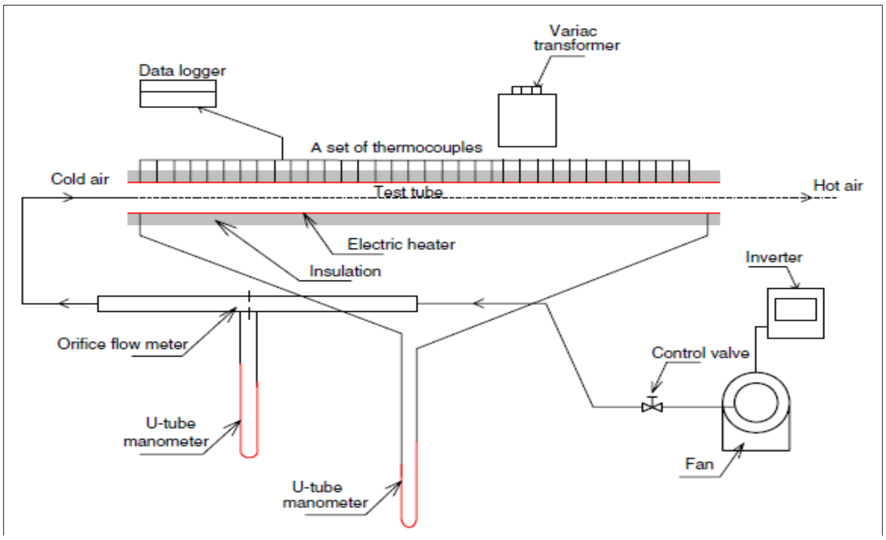


Figure 1 Schematic representation of experimental setup

II Experimental Setup

The experiments were carried out in an open-loop experimental facility as shown in Fig. 1. The loop consisted of a 0.75 kW blower, orifice meter to measure the flow rate, and the heat transfer test section. The copper test tube has a length of L=1250 mm, with 44.5 mm

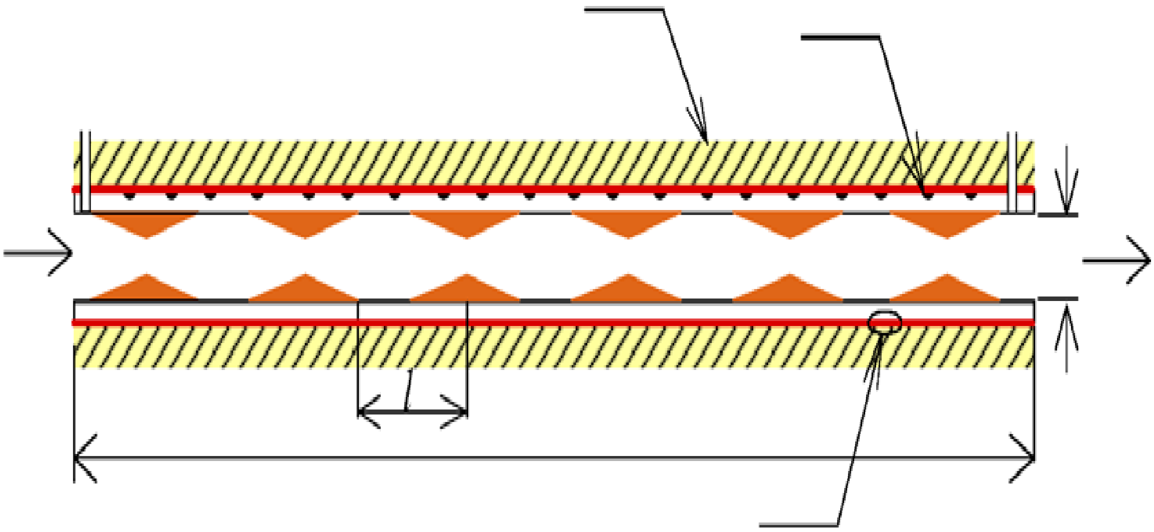


Figure 2 V-NOZZLE Turbulator

inner diameter (D), 49.5 mm outer diameter (Do), and 2.5 mm thickness (t) as depicted in Fig. 2. The tube was heated by continually winding flexible electrical wire to provide a uniform heat flux boundary condition. The electrical output power was controlled by a variance transformer to obtain a constant heat flux along the entire length of the test section and by keeping the current less than 3 A. The outer surface of the test tube was well insulated to minimize convective heat loss to surroundings, and necessary precautions were taken to prevent leakages from the system. The inner and outer temperatures of the bulk air were measured at certain points with a multichannel temperature measurement unit in conjunction with the thermocouples as can be seen in Fig. 2. Six thermocouples were tapped on the local wall of the tube and the thermocouples were laced round the tube to measure the circumferential temperature variation, which was found to be negligible. The mean local wall temperature was determined by means of calculations based on the reading of thermocouples. Fig. 2 represents the V-nozzle arrangement used in the present work. The V-nozzle was made of Mild steel 180 mm in length and its end and throat diameters were 35 mm and 24 mm, respectively. The V-nozzles were placed with pitch ratio PR=5.0 with pitch lengths, l=180 mm for experiment.

Figure 3 Experimental Setup

Figure 4 Fabricated V-nozzle

In the apparatus setting above, the inlet bulk air at 25 °C from a 0.75 kW blower was directed through the orifice meter and passed to the heat transfer test section. The air flow rate was measured by an orifice meter, built according to ASME standard. Manometric fluid was used in U-tube manometers with specific gravity (SG) of 0.981 to ensure reasonably accurate measurement of the low pressure drop encountered at low Reynolds numbers. Also, the pressure drop of the heat transfer test tube was measured with inclined U-tube manometers. The volumetric air flow rates from the blower were adjusted by varying motor speed through the inverter, situated before the inlet of test tube. During the experiments, the the inlet and outlet temperatures of the bulk air from the tube were measured by multi-channel Chromel–constantan thermocouples. It was necessary to measure the temperature at 8 stations altogether on the outer surface of the heat transfer test pipe for finding out the average Nusselt number. For each test run, it was necessary to record the data of temperature, volumetric flow rate and pressure drop of the bulk air at steady state conditions in which the inlet air temperature was maintained at 25 °C. The Reynolds number of the bulk air was varied from 8000 to 18000. The various characteristics of the flow, the Nusselt number, and the Reynolds number were based on the average of tube wall temperatures and outlet air temperature. The local wall temperature, inlet and outlet air temperatures, the pressure drop across the test section and air flow velocity were measured for heat transfer of the heated tube with V-nozzles. The average Nusselt numbers were calculated and discussed where all fluid properties were determined at the overall bulk mean temperature. The experiments are conducted on test rig and bulk air was heated by an adjustable electrical heater wrapping along the test section. Both

3.5 calculations

In the present work, the air is used as working fluid and flowed through a uniform heat flux and insulation tube. The steady state of the heat transfer rate is assumed to be equal to the heat loss from the test section which can be expressed as:

$Qair = Qconv$

in which

$Qair = mCpa(To-Ti)$

The convection heat transfer from the test section can be written as:

$Qconv = hA(Tw-Tb)$

Where as,

$Tb = (To-Ti)/2$

And

$Tw = \sum Tw/6$

where Tw is the local wall temperature and evaluated at the outer wall surface of the inner tube. The averaged wall temperatures are calculated from 6 points, lined between the inlet and the exit of the test pipe. The average heat transfer coefficient, h and the mean Nusselt number, Nu are estimated as follows:

h = mCpa (To-Ti)/A(Tw-Tb)

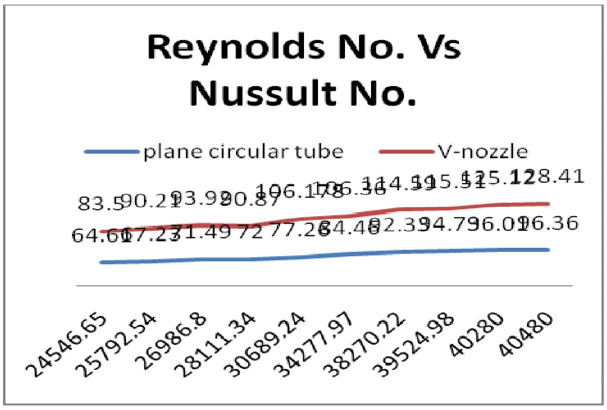
Nu = hD/k

The Reynolds number is given by
Re = UD/v

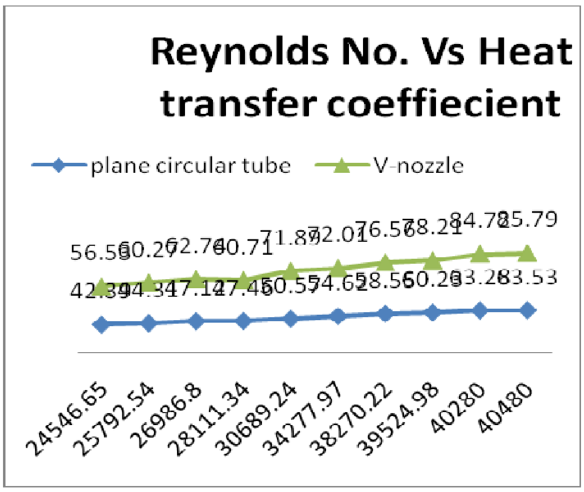
Experimental Results

The experiments were conducted on the test rig initially with the plane circular pipe and the different heat transfer characteristic were calculated and then the same is done for the v-nozzle. The air supply can be controlled by the valve and various mass flow rate are provided for which the heat transfer characteristics are calculated.

The graph shows the relations between Reynolds no and nusselt no. the nusselt no increases with the increase in the Reynolds no. and the Reynolds no increases in the v-nozzle.



The graph shows the relations between Reynolds no and heat transfer coefficient. The heat transfer coefficient increases with the increase in the Reynolds no. and the friction factor increases in the v-nozzle.



Conclusion

Experimental investigations have been carried out to study the effects of the V-nozzle turbulators on heat transfer, and enhancement efficiency, in a circular tube. We used the v-nozzle with the pitch ratio of 5.12 and we found the heat transfer argumentation. The results are

1. The heat transfer in the circular tube could be promoted by fitting with V-nozzles while it brings about the energy loss of the fluid flow. The mean heat transfer rates obtained from using the V-nozzles 147% over the plain tube. However, the increase in friction factor is much higher than the increase in Nusselt number at the same Reynolds number.

2. The enhancement efficiency decreases with increasing Reynolds number. The maximum value of enhancement efficiency obtained from using the 1.09.

References

1. Experimental investigation of heat transfer and friction characteristics in a circular tube fitted with V-NOZZLE TURBULATORS. by S. Eiamsa-ard , P. Promvonge b,
2. Heat transfer and turbulent flow friction in a circular tube fitted with CONICAL-NOZZLE TURBULATORS by Pongjet Promvonge a, Smith Eiamsa-ard.
3. Heat transfer augmentation in a circular tube using V-nozzle turbulator inserts and snail entry Pongjet Promvonge a,*, Smith Eiamsa-ard b,.
4. Heat transfer enhancement in a tube with combined conical-nozzle inserts and swirl generator P. Promvonge *, S. Eiamsa-ard.
5. Heat transfer in a circular tube fitted with free-spacing snail entry and conical-nozzle turbulators☆ P. Promvonge a, •, S. Eiamsa-ard b.
6. Thermal augmentation in circular tube with twisted tape and wire coil turbulators Pongjet Promvonge *
7. Heat transfer behaviors in round tube with conical ring inserts P. Promvonge *
8. Heat transfer behaviors in a tube with combined conical-ring an twisted-tape insert P. Promvonge a, •, S. Eiamsa-ard b.
9. Heat transfer augmentation by swirl generators inserted into a tube with constant heat flux☆ İrfan Kurtbaş a, •, Fevzi Gülçimen b, Abdullah Akbulut c, Dinçer Buran d.
10. Flow-induced vibration analysis of conical rings used for heat transfer enhancement in heat exchangers Kenan Yakut*, Bayram Sahin.
11. Heat transfer enhancement in a tube using circular cross sectional rings separated from wall Veysel Ozceyhan a,*, Sibel Gunes a, Orhan Buyukalaca b, Necdet Altuntop a.
12. The investigation of groove geometry effect on heat transfer for internally grooved tubes Kadir Bilen a,*, Murat Cetin b, Hasan Gul c, Tuba Balta a.
13. Heat transfer – a review of 2000 literature R.J. Goldstein *, E.R.G. Eckert, W.E. Ibele, S.V. Patankar, T.W. Simon, T.H. Kuehn, P.J. Strykowski, K.K. Tamma, A. Bar-Cohen, J.V.R. Heberlein, J.H. Davidson, J. Bischof, F.A. Kulacki, U. Kortshagen, S. Garrick.